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INTEGRATED CIRCUIT PACKAGE HAVING INTEGRAL INPUT/OUTPUT CONNECTORS AND PACKAGING METHOD THEREFOR

STATEMENT REGARDING FEDERALLY-SPONSORED RESEARCH

[0001] Not applicable.

BACKGROUND OF THE INVENTION

[0002] The present invention generally relates to semiconductor integrated circuit (IC) devices. More particularly, this invention relates to an IC package and packaging method by which the package is formed to have integral connector interfaces as its input/output (I/O) leads, thereby enabling the package to be mounted at its point-of-use instead of being mounted to a circuit board equipped with connector interfaces.

[0003] Semiconductor devices are at times enclosed in a protective housing to form an integrated circuit (IC) package, which is then mounted on a circuit board using well known bonding techniques such as soldering and brazing. The devices are typically mounted to a substrate, and then the entire assembly enclosed within a housing to form the IC package. The input/output (I/O) leads between the IC package and the circuit board can be made with the same structures used to mount the package. Connector interfaces will also typically be mounted to the circuit board, by which a cable or other suitable routing connection can be electrically interconnected with the IC package through printed wiring on the circuit board. Consequently, to make an electrical connection to an IC package, both the package and connector interfaces must be mounted to the circuit board.

[0004] While suitably performing the intended purpose, significant process and material costs are incurred with the IC packaging described above. To provide electronics that are more versatile and capable of being mounted at their point-of-use, it can be appreciated that a less complicated and lower cost packaging and assembly process would be highly desirable.

BRIEF SUMMARY OF THE INVENTION

[0005] The present invention is directed to an IC package and packaging method, in which the package can be installed directly at its point-of-use as a result of the package being equipped with integral connector interfaces as its I/O leads, thereby eliminating the need for mounting the package to a circuit board equipped with connector interfaces.

[0006] The IC package of this invention generally includes a conductive support structure that comprises a base portion and at least two sets of electrical connectors extending from the base portion. One or more integrated circuit (IC) devices and any other desired electrical components are mounted to the base portion, and the components are electrically connected to the electrical connectors in a suitable manner. The IC device (as well as any other electrical components) and the base portion of the support structure are enclosed within a housing, with the electrical connectors projecting outside of the housing as input/output connector terminals for the IC device. As such, the electrical connectors of the package allow electrical cables or any other suitable routing connection can be connected directly to the package, instead of being electrically interconnected to the package through a circuit board as conventionally done.

[0007] The packaging method of this invention generally entails mounting the IC device to the base portion of the conductive support structure, appropriately electrically connecting the integrated circuit device to

the electrical connectors, and then enclosing the IC device and the base portion of the support structure in the IC housing for mechanical and environmental protection. The IC housing can be provided in various forms, such as by molding the entire housing or a portion thereof around the IC device and base portion. According to one aspect of the invention, the electrical connections between the IC device and the electrical connectors involve the use of appropriate material combinations that allow for reliable electrical connections between the electrical components and the connectors within the package, while also ensuring that the electrical connectors are sufficiently rugged to survive repeated installations. One such material combination involves the use of a copper alloy as the material for the support structure and aluminum or gold as the material for electrically connecting the IC device to the connectors, where at least those surface regions of the support structure to which the IC device is electrically connected are solderable, and at least the surface regions of the support structure forming the electrical connectors are wear resistant.

[0008] From the above, one can see that the IC package and method of this invention are able to provide a greatly simplified installation by combining two different levels of packaging hierarchy and eliminating the intermediate manufacturing steps associated with mounting an IC package and separate connector interfaces to a circuit board. The IC package provides a protective enclosure for sensitive IC devices, while also providing I/O leads that can be directly connected to cables or other routing connections to allow installation of the IC package at or near its point-of-use, such as with an in-line installation or directly mounted to a motor, light, switch, etc. In addition, the I/O leads and the connections to which they are connected provide a good thermal path to conduct heat away from the IC device within the package. Various connector configurations can be used with the package to provide still greater versatility.

[0009] Other objects and advantages of this invention will be better appreciated from the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Figure 1 is a perspective view if an IC package in accordance with an embodiment of the present invention.

[0011] Figure 2 is a perspective view of the IC package of Figure 1 without a housing to show the internal components.

[0012] Figure 3 shows a leadframe suitable for use with the IC package of Figures 1 and 2.

DETAILED DESCRIPTION OF THE INVENTION

[0013] Figure 1 represents an IC package 10 in accordance with an embodiment of this invention. As illustrated, the package 10 is represented as being suitable for installation on a three-wire buss for an automobile application, though the package 10 could be configured to differ considerably from that shown and used in a wide variety of applications. The package 10 is shown as having an overmolded housing 12 from which two sets of connector terminals 14 and 16 extend. An optional third terminal 18 is shown by which the package 10 can be programmed or electrically tested. The terminals 14 and 16 are represented as having different configurations, though it is foreseeable that the terminals 14 and 16 could be identically configured or have configurations different from those shown, including other types of connector terminals as well as wire cable terminals and solderable terminals. The terminals 14 are shown as insulation displacement connectors (IDC), which strip the outer insulation of a conductor cable (not shown) as the wire of the cable is forced into a slot 20 formed in the end of the terminal 14. The

second set of terminals 16 is shown as "tuning fork" (TF) connectors adapted to mate with a connector having straight blades. While shown as extending from opposite sides of the package 10, the terminals 14 and 16 (and any additional terminals required by the package 10) could extend from essentially any side or surface of the package 10. In addition, the package 10 could be equipped with multiple rows of the terminals 14 and/or 16 for increased density, or to accommodate interconnections from different directions.

[0014] Figure 2 shows the interior components of the package 10, from which it can be seen that a single leadframe 22 forms not only the terminals 14 and 16, but also a base 24 on which the electrical components of the package 10 are mounted. Suitable thicknesses for the leadframe 22 will depend on the material from which the leadframe 22 is formed and the type of terminals 14 and 16 required. Figure 3 is an isolated view of the leadframe 22, and shows the leadframe 22 as initially including an outer support frame 32 that is removed from the final package 10. As is conventional, the support frame 32 supports the interior members of the leadframe 22 with any number of tethers 34, including tethers 34 and 45 that connect adjacent interior members together until removed along with the support frame 32. The base 24 can be seen in Figures 2 and 3 as comprising a segmented frame 26 surrounding two substrate regions 28 and 30 (region 30 is shown surrounded by a solder dam), though any number of substrate regions could be present. The terminals 14 and 16 extend directly from the segmented frame 26, which is shown as being attached to the substrate region 28. Though the second substrate region 30 is shown as being connected to the other substrate region 28 through the solder dam, the region 30 could be completely separate from the other region 28, supported initially by a tether that is subsequently severed. In this manner, the region 30 can be electrically separated from the region 28 (with respect to electrical conduction through the leadframe 22), and may also be electrically separated from the terminals 14 and/or 16.

[0015] Figure 2 further shows two semiconductor chips 36 and 38 and several capacitors 40 and 44 mounted to the base 24 of the leadframe 22. For illustrative purposes, one of the chips 36 is represented as a data bus decoder/control IC, while the second chip 38 is represented as a field effect transistor (FET). The chip 36 is mounted to the substrate region 28, while the FET chip 38 is mounted to the second substrate region 30. Also for illustrative purposes, the capacitors 40 are of a type that can be mounted with conductive adhesive directly to the base 24, while the capacitor 44 can be mounted with insulating adhesive and then wire bonded for electrical connection. Those skilled in the art will appreciate that various other and/or additional semiconductor devices and electrical components (both active and passive) could be used with the package 10 of this invention. The capacitors 40 and 44 are used in the conventional sense to reduce noise, energy storage, etc., between the terminals 14 and 16 and the substrate region 30 on which the chip 36 is mounted. The chips 36 and 38 and the capacitor 44 are shown as having low current wire bonds 42 to make the required electrical connections to the terminals 14 and 16 through the base 24 and its segmented frame 26 and substrate regions 28 and 30. The chip 38 is also provided with a high current wire bond 43.

[0016] The materials for the wirebonds 42 and 43 and the leadframe 22 (and therefore the base 24 and the terminals 14 and 16) must be compatible with each other in order to yield reliable electrical connections, yet also be suitable to perform their respective functions. For example, the leadframe 22 and its terminals 14 and 16 must not only be sufficiently strong, wear resistant, and electrically conductive in order to survive repeated connections, but the leadframe and its base 24 must also be compatible with the chips 36 and 38 and the method by which the chips 36 and 38 are electrically connected to the base 24 and/or terminals 14 and 16. While various material combinations may be possible, a suitable combination employs copper or a copper alloy as the material for the leadframe 22, gold or aluminum for the

wire bonds 42 and 43, a solderable plating (e.g., silver) spot plated only where required for wire bonding, and a more wear-resistant plating for the terminals 14 and 16. Alternatively, the entire surface of the leadframe 22 could be plated with a solderable wear-resistant plating. A preferred material for the leadframe 22 is a 7025 copper alloy completely plated with NiPdAu or NiPd layered plating. Both of these layered plating materials make excellent electrical connectors and are solderable and wire-bondable with gold and aluminum wires. In addition to those noted above, other potential plating materials include NiAu layered plating, tin, and tin alloys such as SnPb and SnAg. A suitable thickness for the leadframe 22 is about 0.1 to about 1 mm, and suitable diameters for aluminum wires for the low and high current wire bonds 42 and 43 are about 1 to 2 mils (about 25 to 50 micrometers) and about 15 mils (about 400 micrometers), respectively, though those skilled in the art will be aware that leadframes and wires of other dimensions could be used, especially if different materials are used. While wirebonding is preferred to make the electrical connections between the chips 36 and 38, capacitor 44 and the leadframe 22, it is foreseeable that other methods could be used to form these connections, such as tape automated bonding (TAB), and soldered metal frames such as copper.

[0017] In assembling and packaging the structure described above, conventional processing can be performed on the chips 36 and 38 to form their respective integrated circuit devices. The chips 36 and 38 and the capacitors 40 and 44 are then mounted on the appropriate portions of the base 24 in any suitable manner, such as by soldering, brazing or a thermally and/or electrically conductive adhesive. The wirebonds 42 and 43 are then formed in accordance with conventional wirebonding methods. The resulting subassembly is then placed in an appropriate mold, and a suitable overmolding compound is injected into the mold to encapsulate the base 24, chips 36 and 38, capacitors 40 and 44, and wirebonds 42 and 43. While various overmolding compounds could be used, a particularly suitable

compound is an OCN epoxy available from Sumitomo Bakelite under the name EMC6600H. Alternatively, the subassembly could be placed in the cavity of a premolded package body which is then filled with a molding compound, or enclosed between interlocking halves of a fully premolded package. Once the housing 12 is complete, the tethers 34 and 45 interconnecting the terminals 14 and 16 and connecting the terminals 14 and 16 and base 24 to the support frame 32 are severed or removed to yield the package 10 shown in Figure 1. Finally, any selective plating desired for the terminals 14 and 16 can be performed at this time.

[0018] In use, the package 10 and its electrical components can be directly connected to a cable (not shown) or any other suitable routing connection having connector interfaces compatible with the terminals 14 and 16 of the package 10. As such, the package 10 is never required to be mounted to a circuit board with separate connector interfaces, allowing the package 10 to be placed at or at least closer to its point-of-use. Particularly notable applications for the package 10 would be as an in-line signal-to-signal conditioner or controller, as well as to boost signal or reduce noise.

[0019] While the invention has been described in terms of a particular embodiment, it is apparent that other forms could be adopted by one skilled in the art. For example, the leadframe 22 and its members could be configured differently from that shown in the Figures and yet achieve the objects of this invention, the package 10 could contain various electrical components for a variety of applications, and different materials could be used than those noted. Accordingly, the scope of the invention is to be limited only by the following claims.

CLAIMS

1. An IC package comprising:

a conductive support structure comprising a base portion and at least two sets of electrical connectors extending from the base portion;

an integrated circuit device mounted to the base portion;

means for electrically connecting the integrated circuit device to the two sets of electrical connectors; and

a housing enclosing the integrated circuit device, the electrical connecting means and the base portion of the conductive support structure, the two sets of electrical connectors projecting outside of the housing as input/output connector terminals for the integrated circuit device.

2. The IC package according to claim 1, wherein a first of the two sets of electrical connectors has a different configuration than a second of the two sets of electrical connectors.

3. The IC package according to claim 1, wherein the electrical connecting means comprises wire bonds.

4. The IC package according to claim 1, wherein the housing is an overmolded body.

5. The IC package according to claim 1, wherein the base portion of the conductive support structure comprises multiple substrate regions separated from each other within the housing, at least one of the electrical connectors being attached to at least one of the substrate regions.

6. The IC package according to claim 5, wherein the integrated circuit device is on a first of the substrate regions and a second electrical component is on a second of the substrate regions.

7. The IC package according to claim 1, wherein the conductive support structure is formed of copper and at least surface regions thereof are solderable, the electrical connecting means are formed of aluminum, and the electrical connecting means are bonded to the solderable surface regions of the conductive support structure.

8. The IC package according to claim 7, wherein the solderable surface regions are formed of plated tin, silver, SnPb alloy, SnAg alloy, NiPd, NiPdAu, and/or NiAu.

9. The IC package according to claim 1, wherein at least a first of the two sets of electrical connectors is connected to a cable.

10. An IC package comprising:

a leadframe comprising a base portion and at least two sets of electrical connectors extending from the base portion, the base portion comprising a segmented frame and multiple substrate regions, each of the electrical connectors being attached to the segmented frame, at least one of the electrical connectors being interconnected through the segmented frame with at least one of the substrate regions;

electrical components mounted to the base portion, at least one of the electrical components being an integrated circuit device mounted to one of the substrate regions;

means for electrically connecting the electrical components to the two sets of electrical connectors; and

an overmolded housing enclosing the electrical components, the electrical connecting means and the base portion of the leadframe, the two sets of electrical connectors projecting outside of the overmolded housing as input/output connector terminals for the integrated circuit device.

11. The IC package according to claim 10, wherein a first of

the two sets of electrical connectors has a different configuration than a second of the two sets of electrical connectors.

12. The IC package according to claim 10, wherein the electrical connecting means comprises wire bonds.

13. The IC package according to claim 10, wherein the leadframe is formed of a copper alloy entirely plated with NiPd or NiPdAu, the electrical connecting means are formed of aluminum or gold, and the electrical connecting means are bonded to the leadframe.

14. The IC package according to claim 10, wherein at least a first of the two sets of electrical connectors is connected to a cable.

15. An IC packaging method comprising the steps of:

providing a conductive support structure comprising a base portion and at least two sets of electrical connectors extending from the base portion;

mounting an integrated circuit device to the base portion;

electrically connecting the integrated circuit device to the two sets of electrical connectors; and

enclosing the integrated circuit device and the base portion of the conductive support structure in a housing so that the two sets of electrical connectors project outside of the housing as input/output connector terminals for the integrated circuit device.

16. The IC packaging method according to claim 15, wherein the conductive support structure is formed so that a first of the two sets of electrical connectors has a different configuration than a second of the two sets of electrical connectors.

17. The IC packaging method according to claim 15, wherein the electrical connecting step is a wirebonding process.

18. The IC packaging method according to claim 15, wherein the enclosing step is an overmolding process comprising the steps of:

placing the conductive support structure with the integrated circuit device mounted thereon in a mold; and then

introducing an overmolding compound in the mold to surround the base portion and the integrated circuit device.

19. The IC packaging method according to claim 15, wherein the base portion of the conductive support structure is formed to comprise multiple substrate regions separated from each other within the housing.

20. The IC packaging method according to claim 19, wherein the integrated circuit device is on a first of the substrate regions and a second electrical component is on a second of the substrate regions.

21. The IC packaging method according to claim 15, wherein the conductive support structure is formed of copper and at least surface regions thereof are solderable, and the integrated circuit device is electrically connected to the two sets of electrical connectors with aluminum connections bonded to the solderable surface regions.

22. The IC packaging method according to claim 21, wherein the solderable surface regions are formed of plated tin, silver, SnPb alloy, SnAg alloy, NiPd, NiPdAu, and/or NiAu.

23. The IC packaging method according to claim 15, further comprising the step of connecting at least a first of the two sets of electrical connectors to a cable.

24. An IC packaging method comprising the steps of:

forming a leadframe comprising a base portion and at least two sets of electrical connectors extending from the base portion, the base portion comprising a segmented frame and multiple substrate regions, each of the electrical connectors being attached to the segmented frame, at least one of the electrical connectors being interconnected through the segmented frame with at least one of the substrate regions;

mounting electrical components to the base portion, at least one of the electrical components being an integrated circuit device mounted to one of the substrate regions;

electrically connecting the electrical components to the two sets of electrical connectors;

placing the leadframe with the electrical components mounted thereon in a mold;

introducing an overmolding compound in the mold to surround the base portion and the electrical components to form an overmolded housing, the two sets of electrical connectors projecting outside of the overmolded housing as input/output connector terminals for the integrated circuit device; and then

detaching the electrical connectors from each other.

25. The IC packaging method according to claim 24, wherein the leadframe is formed so that a first of the two sets of electrical connectors has a different configuration than a second of the two sets of electrical connectors.

26. The IC packaging method according to claim 24, wherein the electrical connecting step is a wirebonding process.

27. The IC package method according to claim 24, wherein the leadframe is formed of a copper alloy entirely plated with NiPd or

NiPdAu, and the electrical components are electrically connected to the two sets of electrical connectors with aluminum connections bonded to the leadframe.

28. The IC packaging method according to claim 25, further comprising the step of connecting at least a first of the two sets of electrical connectors to a cable.

ABSTRACT OF THE DISCLOSURE

An IC package and packaging method, in which the package can be installed directly at its point-of-use as a result of being equipped with integral connector interfaces as its I/O leads, thereby eliminating the need for mounting the package to a circuit board equipped with connector interfaces. The IC package includes a conductive support structure that comprises a base portion and at least two sets of electrical connectors extending therefrom. One or more IC devices and any other desired electrical components are mounted to the base portion, and the devices and components are electrically connected to the electrical connectors. The IC devices, components and base portion of the support structure are enclosed within a housing, with the electrical connectors projecting outside of the housing as input/output connector terminals for the IC devices.

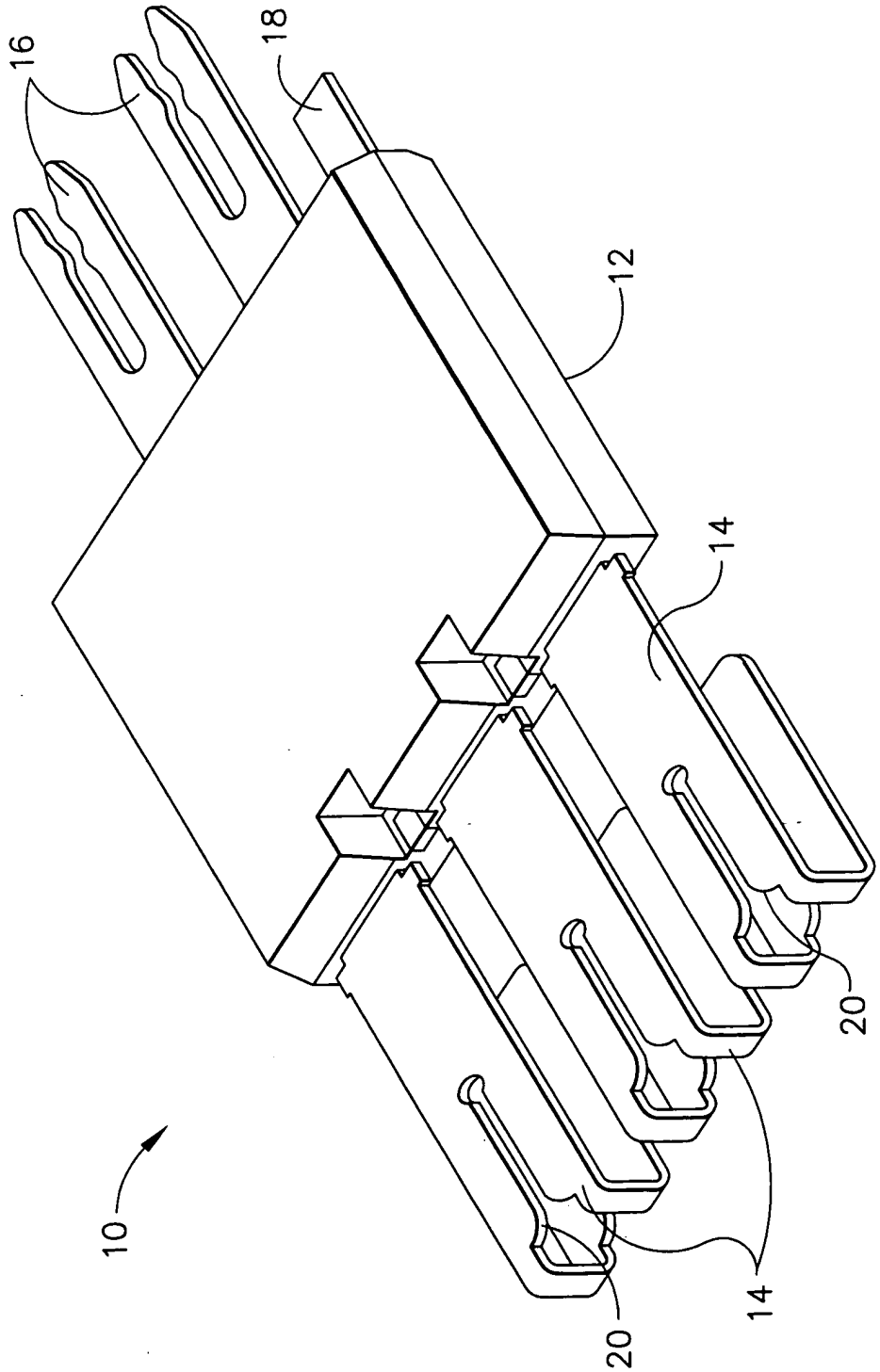

FIG. 1